Laserlab
Europe

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Laserlab Forum

Newsletter of LASERLAB-EUROPE:
the integrated initiative of European laser
infrastructures funded by the European Union's
Horizon 2020 research and innovation programme

New Research Opportunities in Laserlab

The FELIX laser room with FELICE in the upper right side

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www.laserlab-europe.eu

In this Issue

Editorial


Tom Jeltes

At the age of thirteen, when humans enter puberty, Laserlab-Europe seems to have reached adulthood – though it is still growing both in size and in scientific strength. And if the prestigious Advanced Grants from the European Research Council can be considered a relevant yardstick, the quality of the consortium is growing even more rapidly than its size (now 33 full partners, 9 associate partners, and 7 subcontractors): a record number of five ERC Advanced Grants were awarded to Laserlab scientists in the last call. As usual, these projects are described in this issue of Laserlab Forum, as well as several Starting and Consolidator grants.

An important aspect of Laserlab-Europe is the transnational access offered to its research facilities for scientists outside the consortium. As is shown in the Focus section of this issue, our new partners FELIX, FERMI and Coimbra Laser Lab have a lot to offer to the user community. And, of course, the 'old' partners are not standing still either: CLF and LENS have recently been expanded with some exciting new optical techniques, available for scientists from outside Laserlab-Europe too.

Speaking of access: thanks to the facilities and scientists at our partner CUSBO (Milan), Davide Bossini, an Italian PhD student working in Nijmegen (accidentally also home to the new Dutch partner FELIX) was able to conduct a research project recently published in Nature Communications. His contribution can be found in the Access Highlight section.

Much of all this would not have been possible without the efforts of Wolfgang Sandner, the founding father of Laserlab-Europe who died unexpectedly last December as Director General of the ELI Delivery Consortium. In the words of User Representative Rosa Weigand: he leaves a valuable heritage and will be greatly missed.

Tom Jeltes

News

First NEILS meeting at GSI-Darmstadt

Building on the success of the former NAHEL network in Laserlab-Europe, GSI-Darmstadt hosted the first annual meeting of the Networking activity on Extreme Intensity Laser Systems (NEILS) on 9-11 May 2016. A number of 31 participants gathered in Darmstadt, coming from Laserlab-Europe partners GSI, PALS/HILASE, LULI, LP3, CLF, and CEA-CESTA as well as from the Extreme Light Infrastructure (ELI-NP) and the Laserlab-associated laboratory ORION.

The NEILS meeting was centred on round table discussions tackling four subjects: electromagnetic pulse origin and mitigation, laser alignment procedures, component management and target area related issues. As an introduction to the meeting, each laboratory gave a short update on their laser system and enough time was granted in a dedicated session to address specific questions from the ELI-NP team that is in charge of building and operating the next generation short-pulse laser facility. For particularly complicated subjects, short presentations were used to support the discussion or distribute information.


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Inauguration of the International Associated Laboratory MINOS

Two partners of Laserlab-Europe, the Institute of Electronic Structure and Laser (IESL) of the Foundation for Research and Technology-Hellas (FORTH) in Greece and Lasers Plasmas and Photonics Processing Laboratory (LP3 UMR) of Aix-Marseille University and CNRS, have joined recently to create the International Associated Laboratory (LIA) MINOS "Laser Matter Interaction studies from Fundamental to Innovative Laser Processing".

MINOS was officially opened in Heraklion in December 2015 for an initial duration of 4 years; it formalises a collaboration between LP3 and IESL in laser physics, laser-matter interaction, and laser processing which dates back to 1982.

MINOS aims to boost the co-operation between the two institutes in the field of laser-matter interactions at a very short time scale, both from the perspective of scientific excellence as for training of PhD and master students. The new laboratory should improve the European and international visibility of both founding institutions and will provide a bridge across institutes of the Mediterranean region involved in laser sciences.

The scientific program of MINOS is mainly focused on biomimetics with Laser Surface Nanostructuring, laser printing of biomaterials, long-wave strong-field optics in transparent media, laser fabrication of 3D components for ultrasensitive plasmonic biosensoring and nano-LIBS (Laser Induced Breakdown Spectroscopy).

What is Laserlab-Europe?

Laserlab-Europe, the Integrated Initiative of European Laser Research Infrastructures, understands itself as the central place in Europe where new developments in laser research take place in a flexible and co-ordinated fashion beyond the potential of a national scale. The Consortium currently brings together 33 leading organisations in laser-based inter-disciplinary research from 16 countries. Its main objectives are to maintain a sustainable inter-disciplinary network of European national laboratories; to strengthen the European leading role in laser research through Joint Research Activities; and to offer access to state-of-the-art laser research facilities to researchers from all fields of science and from any laboratory in order to perform world-class research.

ICFO leads EU project to develop a device for thyroid cancer screening

The EU-funded project Laser and Ultrasound Co-analyzer for Thyroid Nodules (LUCA) aims to develop a new, low-cost point-of-care device that will provide doctors with enhanced information required to obtain better and more specific results in thyroid nodule screening and enable better diagnosis. LUCA will be led by Turgut Durduran, ICREA Professor at Laserlab-Europe partner ICFO, Barcelona.

Thyroid cancer is a major and growing health challenge with around three hundred thousand new cases diagnosed worldwide annually. Current methods do not provide sufficient support to surgeons in their decision on the appropriate course of action, which leads to a significant number of unnecessary surgeries and a reduced quality of life for patients. Within the LUCA project, a device will be developed which combines ultrasound and near-infrared diffuse optical technologies.

© LUCA

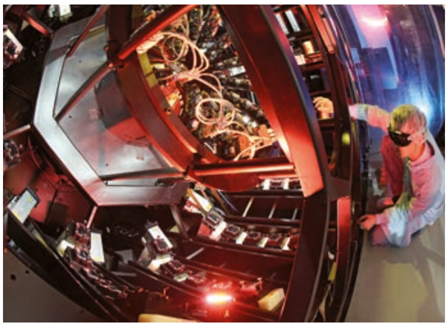
A multidisciplinary team of eight partners, including clinical endocrinologists, radiologists, physicists, engineers and industry players, will carry out this ambitious research project. The first phase of the project will be focused on the development and construction of device components, while the second phase will hopefully see the implementation and clinical validation of the LUCA demonstrator.

www.luca-project.eu

POLARIS laser sets new world record

Scientists from the Helmholtz-Institute Jena (HIJ, partner of Laserlab-Europe) and the Friedrich-Schiller-University Jena have been able to increase the output energy of the laser system POLARIS by more than a factor of three. The achieved pulse energy of 54.16 Joules sets a new world record for a fully diode-pumped, high-power laser system which is based on the technique of chirped-pulse amplification (CPA).

POLARIS is a high-power laser system employing Yb-doped solid state laser materials which are entirely pumped by high-power laser diodes. It is one of the central large-scale infrastructures operated by the Helmholtz-Institute Jena. POLARIS is used for high-intensity experiments on particle acceleration and generation of ultra-short pulses of secondary radiation. Furthermore, the POLARIS laser system is a testbed for other solid-state diode pumped laser systems.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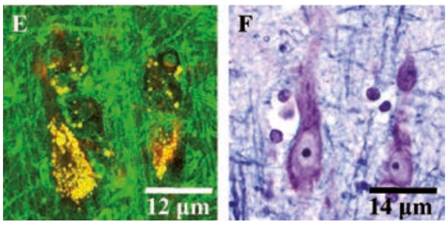
POLARIS Laser System.

Real-time laser identification of brain tumours

Researchers from LaserLaB Amsterdam have shown that a label-free optical technique can reveal exactly where brain tumours are located, producing images in less than a second. The study, led by LaserLaB professor Marloes Groot, might open the way to real-time monitoring of brain surgery in the operating room.



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Brain tissue imaged with lasers (green and red) compared with conventional staining (pink and blue).

Removing brain tumours is particularly challenging, since they are often spread out and mixed in with the healthy tissue. Current staining methods used to distinguish between tumour cells and healthy tissue take up to 24 hours, which means surgeons may not realise some cancerous tissue has escaped from their attention until after surgery.

In the new technique, short laser pulses are sent into the brain; when three photons converge at the same time and place, a single photon is produced which carries information about the tissue. The researchers tested their method on samples of glial brain tumours from humans, finding that the histological detail in these images was as good – if not better – than those made with conventional staining techniques. They were able to make most images in under a minute, rendering their method suitable for real-time monitoring in the operating room.

ERC Grants

The European Research Council (ERC) core funding schemes consist of the Starting Grant (worth up to 1.5 million euro, for top researchers with 2 to 7 years of experience after their PhD), the Consolidator Grant (up to 2 million, 7-12 years after PhD) and the Advanced Grant (up to 2.5 million, for established research leaders). With the latest round of calls, a record number of five Advanced Grants were awarded to scientists from Laserlab-Europe partners. Their projects, as well as three Consolidator Grants and a Starting Grant, are described on these pages.

Optical brain-to-brain communication


Francesco Pavone (LENS) – Advanced Grant

Exchange of information between different brains usually takes place through the interaction between bodies and the external environment. In his Advanced Grant project, Francesco Pavone and his team will try to establish brain-to-brain communication based on full-optical recording and controlled stimulation of neuronal activity in different subjects. As a first step, whole-brain high-resolution imaging in zebrafish larvae will be performed to identify activity patterns related to different tasks. This data will then be used as stimulation patterns in other larvae, in order to gain insight in the complex relationship between neuronal activity and subject behaviour. In addition, brain patterns of mice that recover quickly from strokes will be used as neural activity templates for other animals, as a form of rehabilitation therapy that might eventually be used in humans.

The proton size puzzle


Kjeld Eikema (LLAMS) – Advanced Grant

In 2010, the CREMA collaboration uncovered discrepancies in the energy level structure of muonic hydrogen (where the electron is replaced with a muon) that cannot be explained theoretically. One way of interpreting these results is that the size of the proton is different in normal (electronic) hydrogen compared to muonic hydrogen by as much as 4%. In his Advanced Grant project, Kjeld Eikema will use the novel Ramsey-comb technique to perform precision laser spectroscopy in the extreme ultraviolet on the 1S ground-state to 2S excited state of helium+ ions. Because these ions can be trapped and their energy levels are more sensitive to the size of the nucleus, the helium ion would be especially suitable to provide new clues to solve this 'proton size puzzle' and improve tests of quantum electrodynamic theory.

Creating ultrafast motion with structured laser light


Fabien Quéré (SLIC/LIDYL) – Advanced Grant

High-intensity, ultrashort laser pulses can be used to bring electrons into relativistic motion, where the speed of the particles is no longer negligible compared to the speed of light. This extreme regime of light-matter interaction holds the promise of providing ultracompact laser-driven particle accelerators and attosecond X-ray sources for scientific and medical applications. So far, the quest has been for the highest laser intensities. In his Advanced Grant project, Fabien Quéré aims to establish a new paradigm, by demonstrating the potential of laser-plasma interactions with sophisticated structured laser beams whose amplitude, phase and polarisation are shaped in time and space. Among other techniques, Quéré will use laser fields whose propagation directions rotate on a femtosecond time scale.

Relativistic astrophysics in the laboratory


Luis Silva (IST) – Advanced Grant

In extreme high-energy environments, such as neutron stars or pulsars in outer space, or the focus of ultra-intense laser beams in our laboratories, pairs of electrons and positrons (their antimatter counterpart) can be formed by conversion of electromagnetic energy into massive particles: a direct illustration of Einstein's $E = mc^2$. In his second Advanced Grant project, Luis Silva will use the world's fastest supercomputers to identify the laboratory conditions under which electron-positron pair plasmas will form, and to simulate the extreme astrophysical conditions underlying the behaviour of pulsars. Emphasis will be given to observable signatures of the simulated processes, such as electromagnetic radiation and accelerated particles, in order to create new links between computational studies, laboratory experiments, and relativistic plasma astrophysics.

Carbon nanotubes as sensors of mass and force


© ICFO

Adrian Bachtold (ICFO) – Advanced Grant

Mechanical resonators based on carbon nanotubes are exceptional sensors of mass and force. In his Advanced Grant project, Adrian Bachtold will take advantage of the sensing capabilities of nanotube resonators to study physical phenomena in unexplored regimes. Firstly, he will perform electron spin resonance (ESR) measurements on single molecules in an environment where the magnetic noise is reduced to an unprecedented level. Secondly, Bachtold's team will carry out nuclear magnetic resonance (NMR) on single nuclear spins, which will be imaged using magnetic resonance force microscopy. Lastly, a completely new experimental approach to the investigation of superfluidity is proposed. A nanotube mechanical resonator will be used to probe the superfluidity properties of helium-4 layers adsorbed onto a suspended nanotube.

Rotating attosecond pulses for probing molecular chirality

Yann Mairesse (CELIA) – Consolidator Grant

Chiral molecules come in two forms, so-called enantiomers, which have essentially the same physical and chemical properties, but act differently in a biological setting. Both enantiomers can taste differently, for example, or have contrasting healing powers. Unravelling the workings of chirality would therefore be especially relevant for medicine development, and might even shed light on the origin of life. Because chiral molecules are sensitive to the handedness of light, ultrashort rotating (circularly polarised) laser pulses of attosecond duration can be used to unravel the dynamical aspects of chirality. With his Consolidator Grant, Yann Mairesse will build on a femtosecond technique recently developed at CELIA to create circular attosecond laser radiation, aiming to perform chirality-sensitive attosecond spectroscopy.

Astrophysics with stored radionuclides

All visible matter, except for the lightest elements, is created in the hot interior of stars. Elements heavier than iron are formed via pathways of unstable intermediates, by neutron capture and transmutation of protons into neutrons and vice versa (beta decay). One of the main tasks of modern nuclear astrophysics is to reveal these pathways, which can be accomplished by creating and studying unstable nuclei in terrestrial laboratories. In his Consolidator Grant project, Yuri Litvinov will employ storage rings of 108 meters and 54 meters in circumference at GSI in Darmstadt to observe the transition between several key radioactive ions. The measurements should provide important nuclear data for modelling of astrophysical processes, and would in particular give insight into X-ray bursters and the conditions prior to the formation of the solar system.


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Yuri Litvinov (GSI) – Consolidator Grant

Topology and symmetries in artificial fermionic systems

Leonardo Fallani (LENS) – Consolidator Grant

Fermions are the elementary bricks of our world, from the quarks constituting nuclear matter to the electrons determining the properties of materials. The combined effect of the concepts symmetry and topology poses significant challenges to our comprehension of strongly-correlated matter. In his Consolidator Grant project, Leonardo Fallani will address important open questions concerning topological states of fermionic matter. For this purpose, he will use neutral ytterbium atoms, cooled down to a few billionths of a degree above absolute zero, manipulated and probed by laser light. His aim is to investigate their behaviour under strong magnetic fields, employing laser light to create effective "extra dimensions", and to realize long-sought topological states of matter, such as chiral spin liquids.

Ultracold long-range interactions

Christian Gross (MPQ) – Starting Grant

Ultracold atoms provide an ideal experimental model system for many phenomena in solid-state physics. It is hard, however, to obtain controllable long-range interatomic interactions. In his Starting Grant project, Christian Gross will use a technique called Rydberg dressing to create long-range interactions whose strength, distance dependence, and isotropy can be controlled. He plans to induce Rydberg dressing in ultracold atoms with ultraviolet laser light, enabling him to explore the supersolidity expected in ultracold bosonic systems with soft-core interactions, as well as realize quantum magnets that are designable almost at will and feature unprecedented coupling strengths. As such, his project will not only push the limits for quantum simulators for solid-state physics, but will also create the possibility to experimentally study fundamentally new many-body systems.

New research opportunities in Laserlab-Europe

Another three excellent laser facilities have joined Laserlab-Europe in the fourth phase of its existence. FELIX and FERMI add a variety of free-electron lasers (FELs) to the consortium, whereas Coimbra Laser Lab specialises in lasers for biology and health. This focus section highlights the opportunities that these three new partners offer, as well as some novel techniques that have recently come available at long-time partners LENS and CLF.

The FELIX Laboratory (Nijmegen, The Netherlands)

The FELIX Laboratory (Free Electron Lasers for Infrared eXperiments) at Radboud University exploits intense, short-pulsed infrared and THz free-electron lasers that are used for research of matter both by in-house as well as national and international external users. The FELIX Laboratory is a new partner in Laserlab-Europe and offers access to its free-electron laser beamlines and end stations under the Horizon 2020 programme.

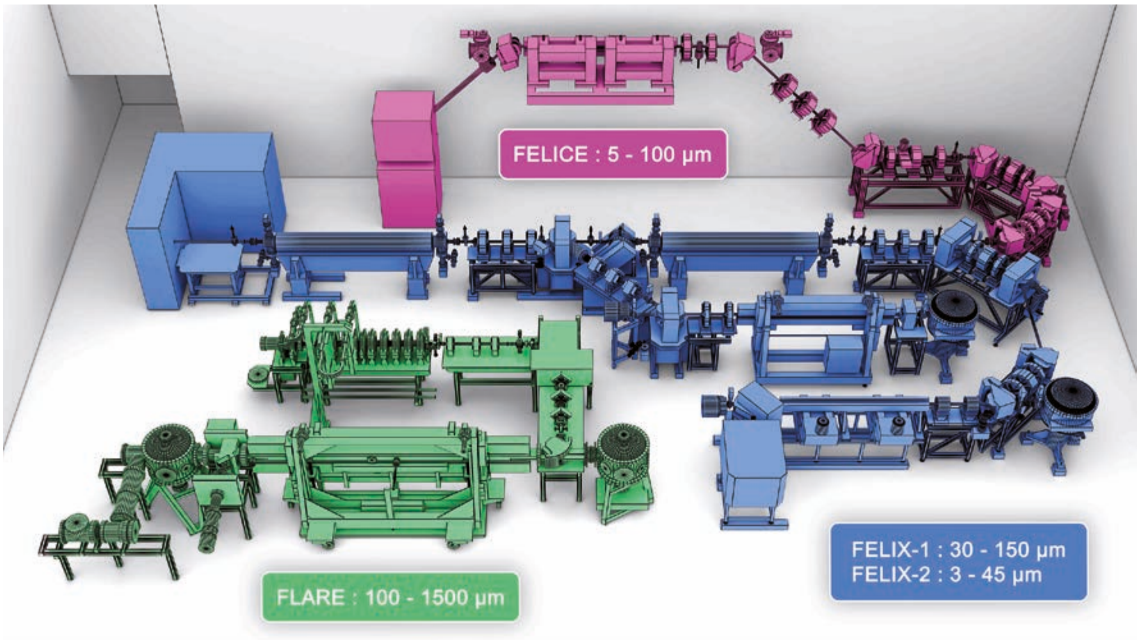
The four lasers FELIX-1, FELIX-2, FELICE and FLARE each produce their own range of wavelengths, and together they provide a tuning range between 3 and 1500 µm – see figure for an overview. The optical pulses generated are transform and bandwidth limited. Primary applications are found in areas benefitting from the wide tunability, high brightness, or the high fluence of the free-electron laser sources.

The energies of the radiation correspond to low energy vibrational, spin and electronic excitations in solids and molecules in solution and gas phase. Therefore, FELIX is ideally suited to study their ground state properties. Research projects include systems such as (bio) molecules, clusters and complexes as well as semiconductors, metals and magnetic materials, using various non-linear and action spectroscopic techniques. The information obtained may serve as a fingerprint to identify species, determine molecular structure, probe quantum coherence, identify chemical bonds, etc.

FELICE, the Free Electron Laser for Intra-Cavity Experiments, is a unique FEL beamline dedicated to intra-cavity experiments. FELICE generates pulsed infrared radiation, tunable in the region of 5-100 µm, and enables optical excitation of molecules and clusters throughout the infrared spectral region in two dedicated experimental setups. FELICE provides unprecedented photon flux: the intensity at the point of the experiment is 50 to 100 times higher compared to the conventional user stations.

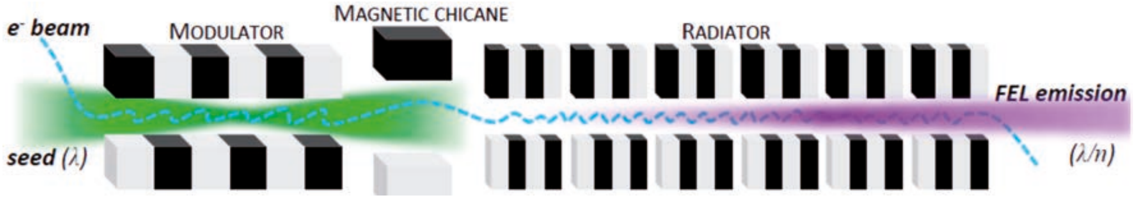
User stations at FELIXThe two user laboratories at the FELIX Laboratory offer access to fifteen user stations in total. Most of the user stations are equipped with advanced experimental setups including different molecular beam machines and ion traps, a He-droplet apparatus, different setups for time-resolved experiments complemented with UV/VIS/IR cw, ns and fs laser sources, magnets, cryostats and more. Combining the radiation of the FELIX lasers with the continuous high magnetic fields of the adjacent High Field Magnet Laboratory (HFML) creates exciting new opportunities. It enables simultaneous studies in high magnetic fields up to 38 T (45 T in 2018) and under intense infrared and THz radiation. These experiments offer scientists the possibility to study matter and materials in conditions that cannot be found anywhere else in the world. For more information, please visit *www.ru.nl/felix/*

Britta Redlich and Iris Kruijen



A schematic overview of FELIX's four lasers.

© FELIX Laboratory, Radboud University



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Scheme of a seeded FEL based on high-gain high-harmonic generation.

FERMI (Trieste, Italy)

FERMI (Free Electron laser Radiation for Multidisciplinary Investigations) is a seeded free-electron laser source based at Elettra Sincotrone Trieste, a multidisciplinary international research centre of excellence located in Trieste, Italy. FERMI is a new partner in Laserlab-Europe.

Unique among the FEL sources currently operating in the ultraviolet and soft x-ray range worldwide, FERMI has been developed to provide fully coherent ultra-short (10-100 femtosecond) pulses with peak brightness ten billion times higher than that made available by third-generation light sources. Thanks to these properties, FERMI is opening unprecedented opportunities for the investigation of the structure and transient states of condensed, soft and low-density matter, using a variety of diffraction, scattering and spectroscopy techniques.

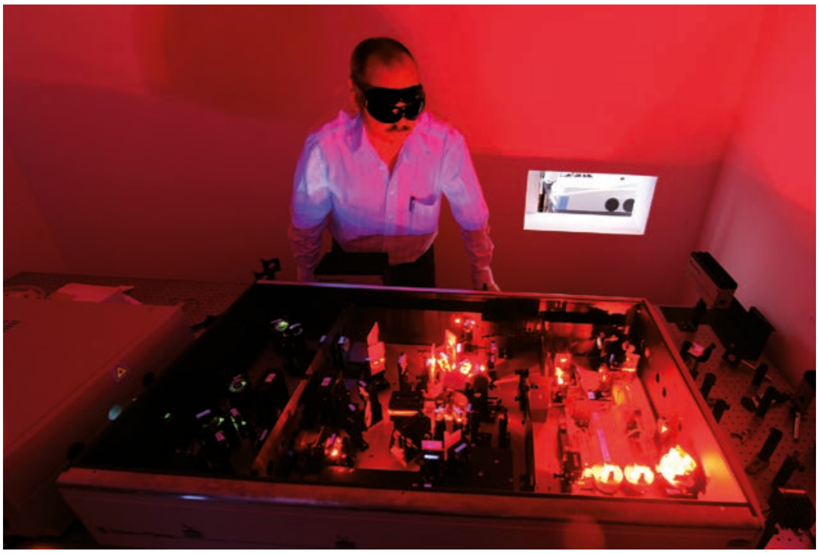
FERMI relies on two undulator lines. The first line, named FEL-1, produces coherent radiation in the spectral range from 100 nm to 20 nm with few GW peak power, and is based on a high-gain high-harmonic (HGHG) scheme with a seed laser and two undulators of different length (the modulator and radiator, see figure). The second line, named FEL-2, covers the spectral range between 20 nm and 4 nm with a peak power of about 1 GW, and is based on a HGHG "double cascade".

Owing to the fact that the seed laser imprints its properties onto the electron beam, the FEL light produced by FERMI is characterized by a very good longitudinal and transverse coherence. Under proper tuning conditions, the generated pulses are close to transform limit and the normalized photon stability is of the order of 7×10^{-5}.

User opportunities at FERMI

In 2015, three beamlines have been available for external users at FERMI: one devoted to elastic and inelastic scattering, one to diffraction and projection imaging, and one to low-density matter studies. A fourth beamline, also devoted to elastic and inelastic scattering is available for external users since 2016. The TeraHertz beamline is under commissioning, while the commissioning of the sixth beamline, devoted to magneto-dynamical studies will start at the end of 2016. For more information, see *www.elettra.trieste.it/lightsources/fermi/*

Giovanni De Ninno



© CLL

Tuning the optical parameter oscillator at the Molecular Cryospectroscopy Lab at Coimbra Laser Lab.

Coimbra Laser Lab (Coimbra, Portugal)

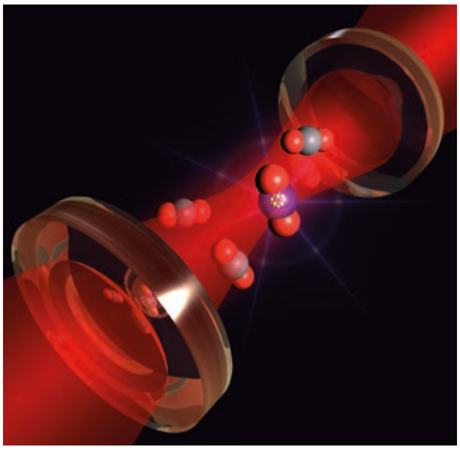
The Coimbra Laser Lab (CLL) is a multidisciplinary laboratory dedicated to the study of interactions between radiation and matter at the molecular level. CLL had been a subcontractor of Laserlab-Europe since 2008, providing user training in lasers and photonics for biology and health. Today, CLL is a full partner of Laserlab-Europe.

The origins of Coimbra Laser Lab go back to 1973, when Sebastião Formosinho returned to Coimbra after his PhD studies with Lord George Porter, Nobel laureate in 1967 for the development of laser flash photolysis. In the 90's, CLL became a European reference for studies with time-resolved photoacoustic calorimetry, UV/VIR/NIR and vibrational photochemistry, and time-resolved fluorescence (ns and ps single photon counting). CLL is currently involved in the Joint Research Activity "Biomedical Optics for Life Science Applications" and offering transnational access to its facilities for external scientists.

CLL is equipped for (femto, pico and nanosecond) laser-induced transient absorption and emission measurements with UV, visible and near-infrared detection, time-resolved photoacoustic calorimetry for solutions and thin films, time-resolved fluorescence decay and anisotropy measurements, fluorescence microscopy, IR and Raman microscopies (with imaging and mapping possibilities), and photochemistry in low temperature matrices. CLL is also able to work with complex systems, such as supercritical fluids, narrow band near-infrared excitation and pulsed vacuum pyrolysis, and possesses a dedicated cell culture laboratory for biological preparations.
www.uc.pt/en/uid/laserlab/

Luis Arnaut

SCAR and I-QEPAS: new roads for trace-gas sensing in the mid IR (LENS)



Radiocarbon dioxide interacting with the laser field in the SCAR setup.

Graphic design by Saverio Bartalini (courtesy of).

Fundamental research and environmental applications demand molecular detection with more and more extreme sensitivity. At long-time Laserlab-Europe partner LENS (Florence, Italy) two novel spectroscopic techniques, SCAR and I-QEPAS, have recently been developed for mid-IR trace gas detection with compact and cost-effective setups. Both techniques are now available for external users via the Transnational Access programme of Laserlab-Europe.

The SCAR (Saturated-Absorption Cavity Ring-down) technique has recently demonstrated a record sensitivity of a few parts per quadrillion for a laser-based sensor, approaching the ultimate sensitivity of accelerator mass spectrometry (AMS). It is designed to meet the challenges in radiocarbon detection with a compact all-optical apparatus, for dating biogenic samples, and for monitoring fossil fuel emissions affecting climate changes. More focused in cost-effective portable devices, the Intracavity Quartz-Enhanced PhotoAcoustic Spectroscopy (I-QEPAS) has been developed within a collaboration with researchers from University and Polytechnic of Bari. It merges the standard QEPAS technique with the power build-up occurring in a specifically-designed high-finesse optical resonator. The prototype, tested on CO_2, shows a sensitivity two orders of magnitude higher than standard QEPAS, which can further be improved by increasing the resonator finesse. This novel system is competitive with the best cantilever-based sensors reported in literature, with the advantage of a simpler and robust detection module.

Simone Borri and
Davide Mazzotti

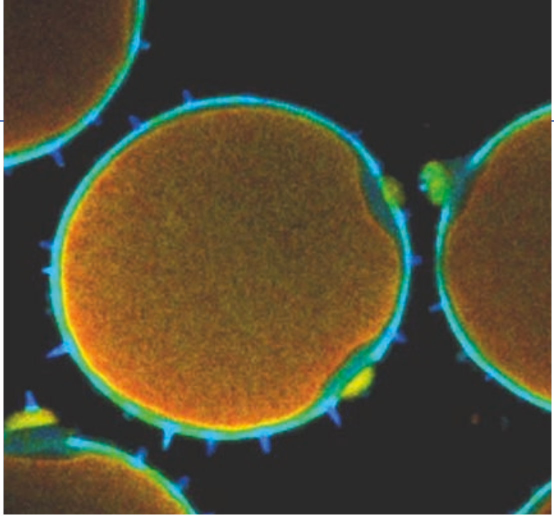


Image: Sarah Gratton and Stan Botchway (CLF)

Fluorescence Lifetime (FLIM) image of pumpkin pollen. Blue and green show longer lifetimes, yellow and orange shorter lifetimes.

New features of ULTRA and Octopus (CLF)

The facilities ULTRA and Octopus, operated by The Central Laser Facility (CLF) at the Research Complex at Harwell (UK), are constantly developing. Their new features add to the possibilities for external users to study dynamics and structure in real world environments such as in solution and in living cells.

Octopus offers access to a range of imaging techniques for imaging samples from single molecules to whole cells and tissues. Octopus is flexible, and users have the freedom to combine multiple beams, colours, and timing capabilities. Development in recent years has been in sub-diffraction limit “super-resolution” imaging, and Octopus now offers the super-resolution techniques of Structured Illumination Microscopy (SIM), localisation microscopy techniques (STORM, PALM) in 2D and 3D, and Stimulated Emission Depletion microscopy (STED).

ULTRA allows users to study molecular dynamics on the femtosecond to millisecond time scales. A recent development for ULTRA has been “LIFEtime”, which has two 100 kHz laser systems and three OPAs providing a UV to mid-IR pump beam and two independently tunable mid-IR probe beams. LIFEtime builds on the Time Resolved Multiple Probe Spectroscopy (TRmPS) technique developed at the CLF. TRmPS uses a pump pulse followed by a train of probe pulses that allow monitoring of processes from the femtosecond to millisecond time scale in a single experiment.

Dave Clarke

Map: CIA World Factbook

Access to Laserlab-Europe’s facilities for scientists from all over the world

The EU-funded transnational access programme enables scientists to have hands-on access to the best laboratories to perform their work, wherever they might be located. This opportunity now has become open also for groups of researchers working in universities or research institutions outside the EU.

The first experiment in this new era of access was performed at LENS, Florence, Italy, by a group of scientists from the Saint-Petersburg Electrotechnical University „LETI“ in Russia. The scientists studied ancient pigments of wall and rock paintings from Russia and Middle Asia by means of non-destructive spectroscopic techniques, such as resonance Raman or surface enhanced Raman spectroscopy under micro-focusing conditions, in order to determine and compare the composition of pigments from different archaeological sites. The results will help to estimate the age of the paintings and will give information on the techniques used in the process of creation of ancient paintings.

In Memoriam: Wolfgang Sandner

Laserlab-Europe mourns the loss of Prof. Dr. Wolfgang Sandner, who passed away unexpectedly on 5 December 2015, at the age of 66 years.


Photo: Ralf Günther

Wolfgang Sandner

Wolfgang Sandner led the establishment of Laserlab-Europe in 2003, after first successfully bringing together, a few years earlier, the major European laser research institutions in the EC network LASERNET. Sandner coordinated Laserlab-Europe continuously from its establishment until 2012. During this time and under his leadership, the consortium grew significantly, geographically as well as scientifically, and accommodated, in particular, partners in the new member states as the EU expanded. He was all the time fully committed to promote the advancement of laser physics and the collaboration of scientists on a European scale.

Wolfgang Sandner studied physics at the University of Freiburg. He received his PhD in 1979 in atomic physics and soon turned to laser physics. After professorships at the universities of Würzburg, Freiburg and Knoxville (Tennessee), he became director of the Max Born Institute for Nonlinear Optics and Short Pulse Spectroscopy (MBI) in 1993 as one of three directors and was appointed Professor of Physics at the Technical University of Berlin.

Wolfgang Sandner was called into many national and international organizations of science and research policy, particularly at the European level. He was advisor of the German Federal Ministry of Education and Research and a member of scientific advisory boards of many research institutes. Wolfgang Sandner was "Fellow of the American Physical Society" (1994) and president of the German Physical Society from 2010 to 2012.

Since 2013 Wolfgang Sandner was Director General of the ELI Delivery Consortium International Association managing the establishment of the Extreme Light Infrastructure (ELI) as a joint European effort with three research institutions in the Czech Republic, Romania and Hungary.

A note of gratitude

We were deeply saddened to learn that Professor Wolfgang Sandner, the first Coordinator of Laserlab-Europe, passed away on 5 December 2015.

For those who didn't know him personally, reading the numerous commemorations from important organizations and centres will provide a first impression of his outstanding scientific achievements and organizing abilities.

To us, users of one of the most successful networks of large-scale research infrastructures in the EU, he was mainly known as the foundation stone of Laserlab-Europe, an organization that, since its creation in 2003, has grown in strength and, now in its fourth edition, gathers 33 organizations from 16 countries.

Over these years, we have perceived how challenging it must have been, in the light of the strong competition with other scientific areas, not only to create Laserlab-Europe, but also to secure funding for extending its activities through several phases. Wolfgang Sandner's clear vision and broad-ranging perspective on the best strategies and approaches towards success were truly remarkable, and have been key to the accomplishments of Laserlab-Europe. As a result, we users have been privileged to enjoy the opportunity of performing scientific experiments at world-class laboratories, which would otherwise have been impossible in our local facilities. The scientific richness that this has given us is highly significant, not only to the individual researchers, but also to our departments, universities and ultimately - since knowledge spreads - to our countries.

We should not forget to mention that he was a very friendly, straightforward person who could connect on a personal level with virtually all members of the Laserlab-Europe committees, including the User Representatives. We shall greatly miss him.

He leaves a valuable heritage. On behalf of all users in Laserlab, we want to express our gratitude for his vision, dedication and hard work for the benefit of all of us.

Thank you so much, Wolfgang.

Rosa Weigand
on behalf of all Laserlab-Europe
User Representatives

Laser pulses push spintronics to the limit

Ultrashort laser pulses can be used to manipulate magnetic materials. This technique might lead to ultrafast information technology, unrestrained by heating issues. In a transnational access project, performed at Laserlab-Europe partner CUSBO (Milan, Italy), Davide Bossini and his co-workers from Radboud University Nijmegen (The Netherlands) demonstrated all-optical excitation, detection and control of the magnetic properties of antiferromagnets on a femtosecond timescale and nanometer length scale. Their results were recently published in Nature Communications.

The research activity concerning the interaction between ultrashort laser pulses and magnetic materials has developed into one of the most interesting and open areas in condensed matter physics. The scientific reason for this growing popularity lies in the fundamental interest of this research field. The borders of the human knowledge of magnetic phenomena have been dramatically broadened by the investigation of non-equilibrium states induced by femtosecond laser pulses. This regime has revealed magnificent phenomena utterly forbidden in equilibrium, such as the ultrafast demagnetization[1] of metallic ferromagnets and the picosecond reversal of the magnetization in a ferrimagnetic metallic alloy[2,3].

The ultimate goal of this exciting scientific journey consists in manipulating the macroscopic magnetic order on the femtosecond timescale and nanometer length scale simultaneously, in the absence of any energy dissipation. Such a result would allow the development of an ultrafast information processing technology unrestrained by heating issues, which could be miniaturized to the nanometer range.

Materials exhibiting fast spin dynamics and low optical absorption, thus avoiding laser-induced heating, are the best candidates to achieve such an ambitious goal. These properties were identified in dielectric antiferromagnets, i.e. magnetically ordered materials with at least two spin sublattices with different orientation (see Fig. 1a).

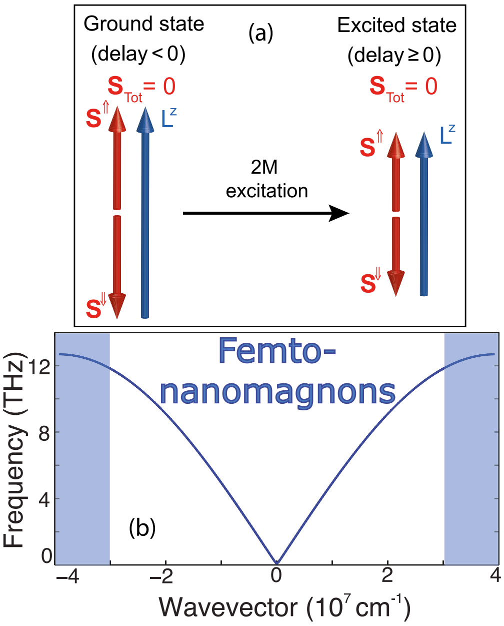


Figure 1: *(a) An antiferromagnet consists of two equivalent magnetic sublattices pointing in different directions. The vectorial difference of the two sublattices, the antiferromagnetic vector (**L**) is the order parameter. (b) The dispersion of the magnons in* $KNiF_3$ *shows that the frequency increases monotonically as a function of the wave vector.*

A decade ago it was realized that laser pulses can excite coherent collective spin excitations, called spin waves (or magnons), via the non-resonant impulsive stimulated Raman scattering mechanism[4] (ISRS). The early observations[5,6] involved magnons with wave vectors around the center of the first Brillouin zone, which are the lowest-frequency magnons in the typical dispersion of an antiferromagnet (see Fig. 1b). This excitation was demonstrated even in the total absence of photo-induced heating of electrons and the lattice[7]. However, this elegant optical approach seemed to be applicable only to low-energy and long wavelength spin waves, because the negligible wave vector of light usually restricts the excitation of collective eigenmodes to the center of the Brillouin zone. Consequently, the potential of the all-optical scheme to manipulate spins appeared to be fundamentally limited to the picosecond timescale and micrometer length-scale.

Interestingly, Raman spectroscopy performed in equilibrium states revealed that a light beam can couple to high-energy magnons, with a wave vector near the edges of the Brillouin zone. The conservation of wave vector and angular momentum are granted by the generation of pairs of interacting magnons, with wave vector equal in magnitude and opposite in sign, originating from spin-flip events on both sublattices (see Fig. 1a). For this reason the resulting state is called two-magnon (2M) mode. The period and the wavelength of the spin excitations near the edges of the Brillouin zone are in the femtosecond time- and nanometer length-scale respectively. Therefore such spin waves have been defined *femto-nanomagnons*.

Although it may be expected that a laser pulse can trigger the 2M mode via ISRS, the subsequent spin dynamics is terra incognita. A characterization of the regime of spin dynamics induced by femto-nanomagnons requires a time-resolved investigation. Relying on the pump-probe scheme, the dynamical spin response of the photo-excited sample is obtained via the detection of magneto-optical effects, expressed by the modification of the probe beam polarization.

In the case of the 2M mode, this is extremely challenging from an experimental point of view. Not only are laser pulses as short as 10 femtoseconds required for a successful ISRS excitation, but also the photon energy has to be tunable in order to avoid any lattice or electronic laser-induced heating[7]. Moreover, the possibility to cool the sample down to liquid nitrogen or even helium temperature would allow studying materials not magnetically ordered at room temperature.

The demand for such a state of the art set-up could be met only via the Laserlab network. More precisely, the CUSBO facility at the Physics Department of Politecnico in Milan is specialized in the development of optical set-ups delivering sub-10 femtosecond laser pulses spanning the visible and near infrared spectral ranges. A tight collaboration with Giulio Cerullo and Stefano Dal Conte allowed my collaborator A.V. Kimel (Radboud University Nijmegen) and me to excite the Heisenberg antiferromagnet $KNiF_3$ with 10 femtosecond laser pulses with

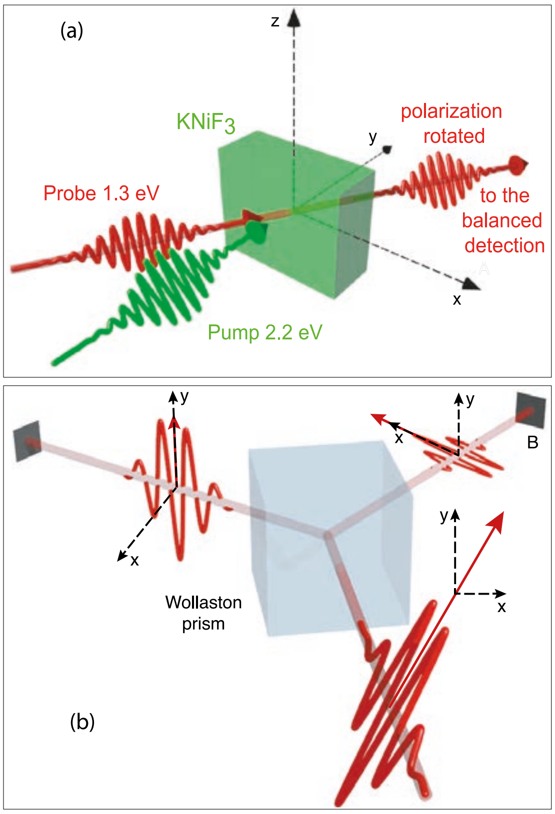


Figure 2: *(a) Schematic of the experimental approach. An intense laser pulse, the pump, excites the sample. A second weaker beam, the probe, detects the pump-induced dynamics in the sample via a rotation of the polarization. (b) The rotation of the polarization is detected in the balanced-detection scheme.*

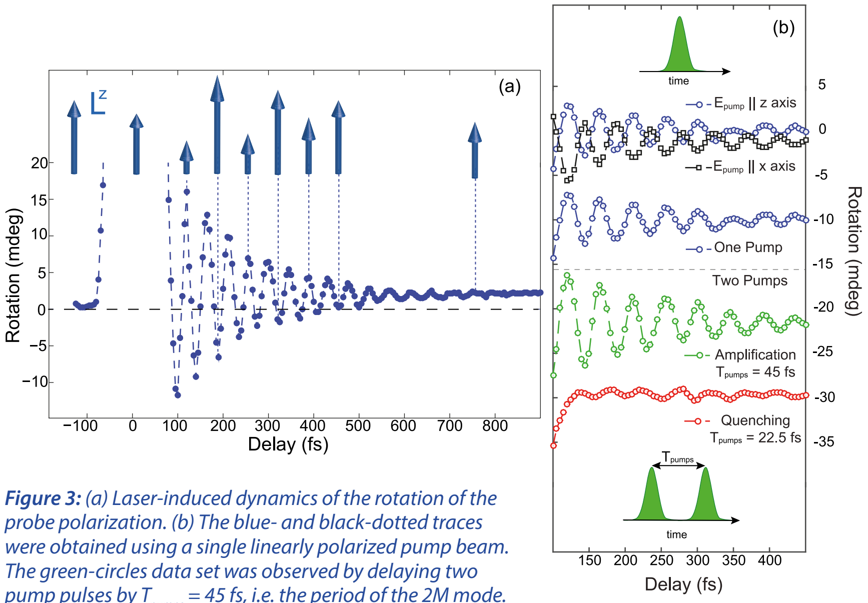


Figure 3: *(a) Laser-induced dynamics of the rotation of the probe polarization. (b) The blue- and black-dotted traces were obtained using a single linearly polarized pump beam. The green-circles data set was observed by delaying two pump pulses by T_{pumps} = 45 fs, i.e. the period of the 2M mode. The coherent amplification of the signal is observed.*

2.2 eV central photon-energy. The probe was tuned to 1.3 eV, since the material is highly transparent in this spectral region.

Schematic representations of the experimental setup and concept of detection are shown in Fig. 2. Our data display oscillations at the frequency of 22 THz and lifetime of 500 fs, which are consistent with the energy and bandwidth of the 2M-mode observed via Raman spectroscopy (see Fig. 3a). Moreover, the temperature dependence of the signal confirmed the identification of the observed oscillations with the 2M-mode. This entails that the signal shown in Fig. 3a corresponds to coherent magnons with the frequency of 22 THz and wavelength of 1 nm, opening up the novel *femto-nanomagnonics* regime discussed above.

While an ISRS excitation could be anticipated, we disclose here the dynamics of the magnetic system induced by such an unprecedented excitation. An analytical quantum mechanical model demonstrates that the generation of the 2M-mode cannot give rise to any macroscopic spin precession[8]. In the same framework, we demonstrate that the data in Fig. 3a represent solely longitudinal coherent oscillations of the antiferromagnetic vector (see Fig. 1), which is the order parameter in an antiferromagnet. As a consequence, during the whole lifetime of the signal in our experiment the magnetization is constantly vanishing. On top of that, we even demonstrated a coherent manipulation of the amplitude and phase of the magnonic oscillations, employing a double-pulse excitation scheme (see Fig. 3b).

To sum up, our experiment demonstrated an all-optical excitation, detection and control of the order parameter in antiferromagnets on the femtosecond timescale and nanometer length-scale simultaneously. These antiferromagnetic materials have been recently massively studied because of their technological potential, which has been hitherto hampered by the lack of efficient approaches to the manipulation of their magnetic order.

The ability to monitor the femtosecond dynamics of spin-excitations, with wavelength comparable with the nearest-neighbour distance, discloses also novel possibilities for future fundamental studies. For instance, our approach allows the detection of the real-time evolution of nanometer spin-spin correlations in strongly-correlated materials, even during magnetic phase transitions. This might elucidate the interplay between short-range spin excitations and high-temperature superconductivity in cuprates.

Davide Bossini

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"Wolfgang Sandner" Scientific Excellence Prize for Young Researchers

The Extreme Light Infrastructure (ELI) has established a new prize for early career scientists in commemoration of Wolfgang Sandner, who died in December 2015 as Director of the ELI Delivery Consortium International Association.

The Wolfgang Sandner Prize recognizes outstanding instrumental, experimental or theoretical contributions to the scientific field of extreme light research and applications. The prize will be awarded by ELI to a young researcher who defended his/her Ph.D. less than 7 years ago, and who has made significant contributions to the field over the past decade, including the doctoral thesis.

The first edition of the prize will be awarded at the occasion of the ELI Summer School (ELISS 2016), which will take place 21-26 August 2016 at ELI Beamlines Dolni Břežany, Czech Republic. The prize consists of a lecture at the school, allowing the awardee to present its research results, the full coverage of the attendance of the school (travel and subsistence costs), and a cash prize. The prize is sponsored by the ELI Delivery Consortium (ELI-DC) International Association.

Three million euros for European Plasma Research Accelerator with eXcellence In Applications (EuPRAXIA) project

The European Union supports the development of a novel plasma particle accelerator with three million euros from the Horizon2020 program. The EU project EuPRAXIA (European Plasma Research Accelerator with eXcellence In Applications) will produce a design study for a European plasma research accelerator focussing on applications of the new technology. Plasma acceleration promises to shrink costs and size of particle accelerators for science, medical applications and industry significantly.

"EuPRAXIA will define the missing step towards a new generation of plasma accelerators with the potential for dramatically reduced size and cost," said EuPRAXIA coordinator Ralph Assmann from DESY, the German national laboratory for high-energy physics. "It will ensure that Europe is kept at the forefront of accelerator-based science and applications." The EuPRAXIA consortium includes 16 laboratories and universities from five EU member states. In addition, it includes 18 associated partners from eight countries, involving leading institutes in the EU, Japan, China and the United States.

The project will produce a design report for accelerator technology, laser systems and give feedback for improving the quality of plasma-accelerated electron beams.

To find out more about the project visit *www.eupraxia-project.eu*.

Carsten P. Welsch
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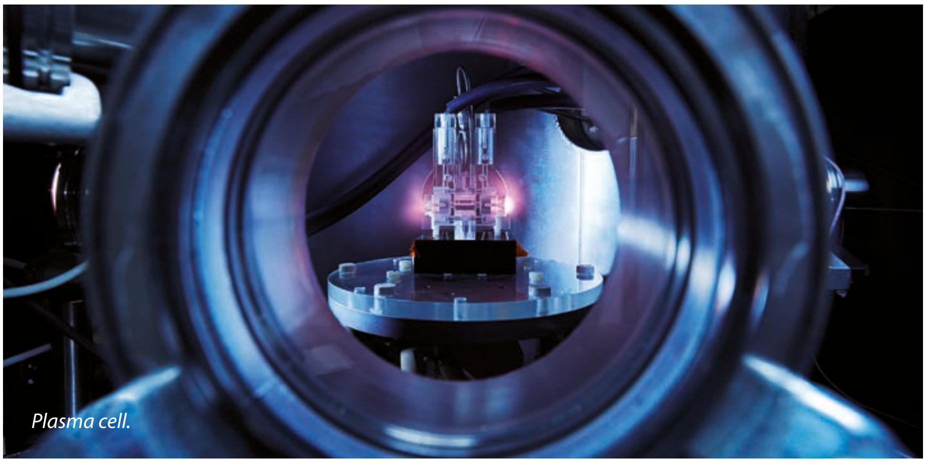
Plasma cell.

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Forthcoming events

Building a Target Network for Advanced Laser Light Sources
EUCALL Satellite Workshop,
co-organised by Laserlab
29-31 August 2016, Dresden, Germany

Science@FELs 2016
5-7 September 2016, Trieste, Italy

Laserlab User Meeting
29-30 September 2016, Crete, Greece

CLF Laserlab Experimental Training School
Nov 2016, Harwell Oxford, UK

To find out more about conferences and events, visit the Laserlab online conference calendar.

How to apply for access

Interested researchers are invited to contact the Laserlab-Europe website at www.laserlab-europe.eu/transnational-access, where they find all relevant information about the participating facilities and local contact points as well as details about the submission procedure. Applicants are encouraged to contact any of the facilities directly to obtain additional information and assistance in preparing a proposal.

Proposal submission is done fully electronically, using the Laserlab-Europe Proposal Management System. Your proposal should contain a brief description of the scientific background and rationale of your project, of its objectives and of the added value of the expected results as well as the experimental set-up, methods and diagnostics that will be used.

Incoming proposals will be examined by the infrastructure you have indicated as host institution for formal compliance with the EU regulations, and then forwarded to the Access Selection Panel (ASP) of Laserlab-Europe. The ASP sends the proposal to external referees, who will judge the scientific content of the project and report their judgement to the ASP. The ASP will then take a final decision. In case the proposal is accepted the host institution will instruct the applicant about further procedures.

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